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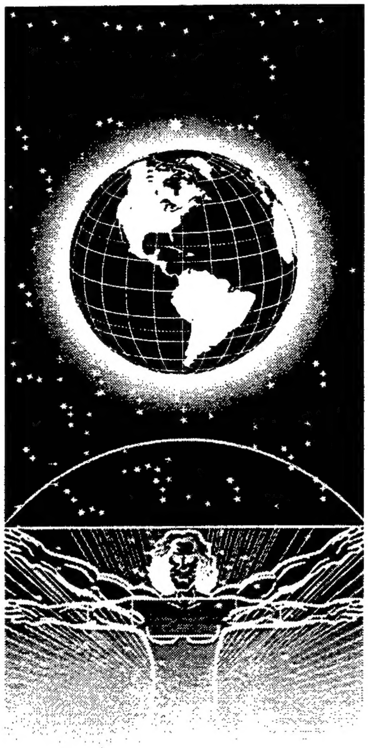

UNITED STATES AIR FORCE RESEARCH LABORATORY

Windblast Facility Evaluation

Joseph A. Pellettiere
Thao Q. Nguyen
Charles C. Nguyen

AIR FORCE RESEARCH LABORATORY

February 2003

Interim Report for the Period June 2000 to May 2001

Human Effectiveness Directorate
Biodynamics and Protection Division
Biodynamics and Acceleration Branch
2800 Q Street, Bldg 824, Rm 206
Wright-Patterson AFB OH 45433-7947

NOTICES

TECHNICAL REVIEW AND APPROVAL

AFRL-HE-WP-TR-2003-0060

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE DIRECTOR

F. Wesley Baumgardner

F. WESLEY BAUMGARDNER, PhD
Chief, Biodynamics and Protection Division
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
February 2003	Interim	June 2000 - May 2001

4. TITLE AND SUBTITLE Windblast Facility Evaluation	**5a. CONTRACT NUMBER** 00-127-HE-01
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER 62202F
6. AUTHOR(S) Joseph A. Pellettiere, Thao Q. Nguyen, Charles C. Nguyen	**5d. PROJECT NUMBER** 7184
	5e. TASK NUMBER 718402
	5f. WORK UNIT NUMBER 71840205
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory, Human Effectiveness Directorate Biodynamics and Protection Division Biodynamics and Acceleration Branch 2800 Q Street, Bldg 824, Rm 206 Wright-Patterson AFB OH 45433-7947	**10. SPONSOR/MONITOR'S ACRONYM(S)**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) AFRL-HE-WP-TR-2003-0060

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The windblast test facility at Dayton T. Brown (DTB) was recently reconstructed with several modifications. These modifications were aimed at improving airflow uniformity and increasing the effective blast area. AFRL has routinely used the facility at DTB in its research programs and collaborated with DTB on the evaluation of the facility upgrades. Fifty-two windblast tests were conducted with airspeeds ranging from 375-725 Knots Equivalent Airspeed (KEAS). During these tests the flow at the location of where test articles would be placed was measured. The resulting flow was used to calculate the velocity decay from the windblast nozzle to the test article as well as determine the airflow uniformity across the test article space. It was determined that the airflow was uniform and the system was capable of producing a 700 KEAS blast.

15. SUBJECT TERMS
Windblast testing, Ejection safety, Test methods

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Joseph A. Pellettiere
UC	UC	UC	UL	46	**19b. TELEPHONE NUMBER** *(Include area code)* (937) 255-1150

Standard Form 298 (Rev. 8/98)
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PREFACE

The research described in this report was conducted by personnel of the Biodynamics and Acceleration Branch, Biodynamics and Protection Division, Human Effectiveness Directorate of the Air Force Research Laboratory (AFRL/HEPA) from 19-27 June 2000 and 7-11 May 2001. The testing was conducted at the Dayton T. Brown test facilities in Bohemia NY.

Mr. Thao Nguyen of AFRL/HEPA served as the principal investigator and project manager with Dr. Joseph A. Pellettiere and Capt Charles Nguyen as the associate investigators. This project was completed under the Cooperative Research and Development Agreement (CRADA) No. 00-127-HE-01 between AFRL/HEPA and Dayton T. Brown Inc.

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INTRODUCTION AND OVERVIEW

The Air Force Research Laboratory (AFRL) has considerable expertise in the windblast testing and analysis of ejection seats, life support equipment, and helmet-mounted displays (HMD). During the development of these systems, windblast testing can be utilized as a tool to provide data for an initial evaluation of the test article's structural and aerodynamic qualities prior to conducting sled ejection or flight tests. The Visually Coupled Acquisition and Targeting System (VCATS), Panoramic Night Vision Goggle (PNVG), and Joint Helmet Mounted Cueing System (JHMCS) are a few HMD's previously windblast tested by AFRL for structure integrity and ejection seat compatibility.

Two areas that influence test data accuracy are airflow uniformity and coverage area. A non-uniform airflow will create an uncontrollable pressure distribution across the test article. The coverage area of the blast nozzle must be large enough to encompass the entire test article and still provide airflow uniformity. Video footage of previous windblast tests show that test articles had the tendency to rotate excessively when exposed to non-uniform airflow. The seat pitot interference potentials could not be accurately determined for several ejection seats including the ACES II because the pitot tubes were not fully covered by the windblast airflow. Enhanced performance in these areas is expected at the Dayton T. Brown (DTB) windblast facility in New York after a recent developmental effort where a new system was designed and constructed. Among the enhancements of the new DTB facility are a windblast nozzle assembly which has been increased in width by a factor of 50% to a dimension of 3 feet x 5 feet, and an airflow delivery system which incorporates a symmetrical design that improves airflow uniformity. In addition to these improvements, the facility can produce 700 KEAS airspeed at the test article, which makes it possible to accommodate more demanding future testing requirements.

A test program was conducted to survey the airflow profile of the new DTB windblast facility. This effort was completed under the Cooperative Research and Development Agreement (CRADA) No. 00-127-HE-01 between the Biodynamics and Acceleration Branch of the Air Force Research Laboratory (AFRL/HEPA) and Dayton T. Brown Inc. In return, DTB provided windblast conditions at no cost to the Air Force during planned future testing of the Panoramic Night Vision Goggle (PNVG).

This data report contains the results of fifty-two (52) windblast tests conducted at nozzle airspeeds ranging from 375 to 725 Knots Equivalent Airspeed (KEAS) (Table 1). The test-measuring device was a pressure rake consisting of three sensor bars that provided a mounting structure for 63 pressure transducers (Figure 1). The design of the rake was verified through computational analyses (Appendix B). The data collected were used to determine the airflow characteristics of the new windblast facility.

Table 1. Test Matrix

Cell	Test Speed at Windblast Nozzle (KEAS)	Pressure Rake to Nozzle Distance (inches)	Vertical Position of Sensor Bars (Slots 1 - 24)[1]
A	375	58.7 [2]	1-24
B	475	58.7	1-24
C	625	58.7	1-24
D	725	58.7	1-24
E	475	24, 72	4,12,20
F	375	24, 72	4,12,20
G	625	24, 72	4,12,20
H	725	24	4,12,20
I	375	58.7	1-9
J	475	58.7	1-9
K	625	58.7	1-9
L	725	58.7	1-9

<u>Notes</u>:

a. [1] The slots are labeled 1 through 24, starting at the top of the rake and spaced 2½ inches apart. The sensor bars are separated by a span of 8 slots (20 inches).

b. [2] The nominal distance from the windblast nozzle to the test article is 58.7 inches.

c. Eight tests were required for each cell from A through D. These tests were conducted with the sensor bars adjusted to eight different heights until the entire cross-section of the nozzle was completely covered.

d. Two tests were conducted for each cell from E through G and one test for cell H. The three sensor bars were mounted at slots 4, 12, and 20 respectively.

e. Cells I through L are repeats of cells A through D for slots 1 through 9 due to sensor failures on the top row of the pressure rake.

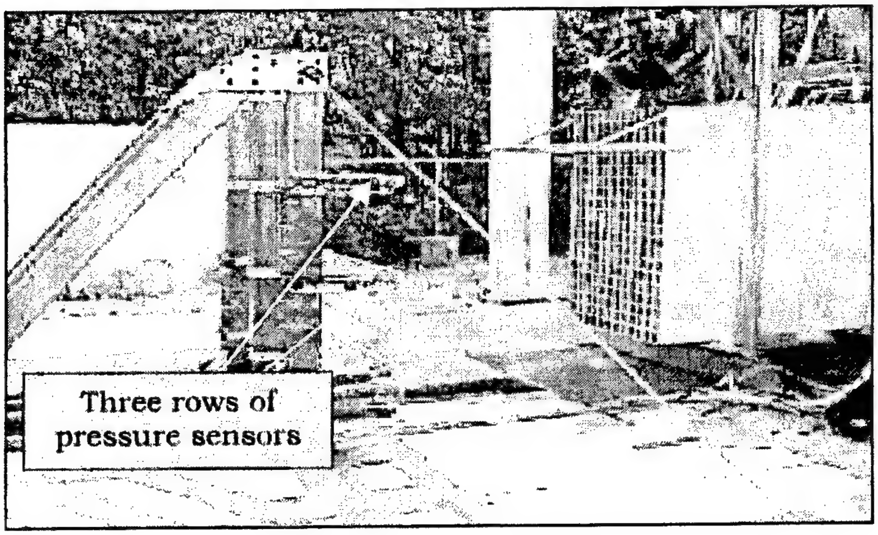

Figure 1. Test Setup

TEST DESCRIPTION

The purpose of the tests was to survey the airflow profile of the new DTB windblast facility. The tests were performed at windblast nozzle airspeeds of 375, 475, 625, and 725 KEAS. The test was conducted with a pressure rake assembly. A total of 63 transducers were mounted on the rake to collect pressure data. The statistics of the airflow velocity were calculated to determine the flow uniformity and coverage area.

DATA COLLECTION AND PROCESSING

During these windblast tests, the data were collected at 5,000 Hz using the Data Acquisition System (DAS) low-pass filter of 1,250 Hz.

After the data was collected and downloaded to the computer, the data were viewed through the DAS software to provide a quick look. The data were extracted and converted to ASCII format using the DAS software. The extracted data starting point was at the time of windblast valve opening. The time duration of the data was 2.00 seconds. The data were zeroed using the data collected immediately prior to the windblast valve opening. The data were decimated to a 100-Hertz sample rate.

To construct the airflow pressure profile, the peak measurements were normalized using the Pressure Correction Factor (PCF) for each test (see Appendix A). To compare the findings based on the aerodynamic loads, the measured pressure at the windblast nozzle was used to compute the PCF. The PCF is the ratio of the dynamic pressure corresponding to the planned test speed at the windblast nozzle and the actual output pressure measured at the windblast nozzle. This assumes that the dynamic pressure is linear within ±20 KEAS.

Personnel from Dayton T. Brown were responsible for pressure rake setup, operation of the windblast facility, and safe conduct of the test. The Biodynamics and Acceleration Branch

personnel provided sensor instrumentation, data collection and processing, and data summary. The AFRL engineers on site for this test were Mr. Thao Nguyen and Capt Charles Nguyen (AFRL/HEPA).

TEST RESULTS

All DAS data channels were recorded and downloaded successfully. The following are summaries for each test condition.

1. <u>375 KEAS and 58.7" from the Windblast Nozzle</u>: The nozzle produced a mean velocity of 347 KEAS with a standard deviation of 15 KEAS. The velocity decay from the nozzle to the test fixture was 28 KEAS. See Figure 2.

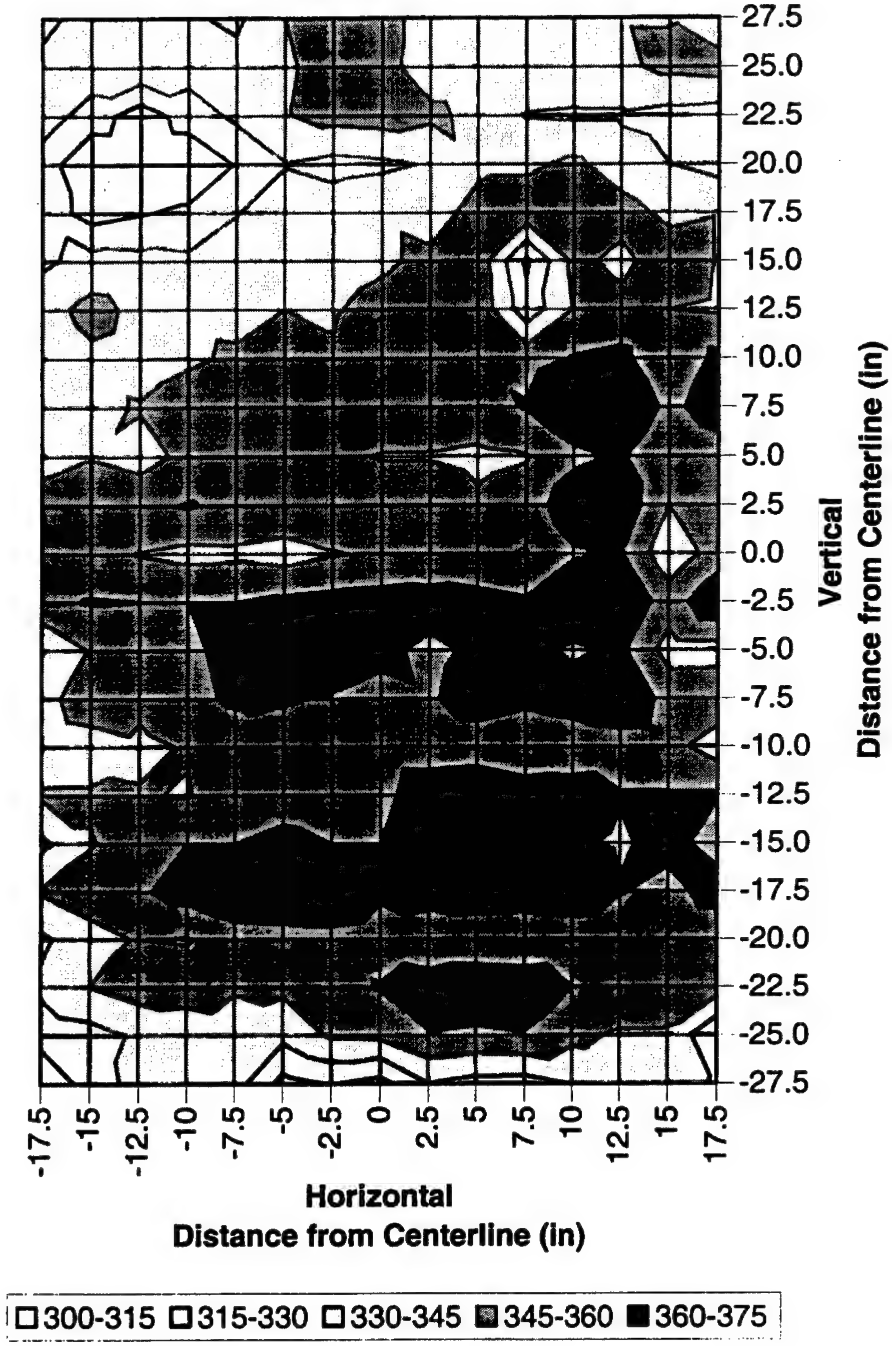

Figure 2. Velocity Profile (in KEAS) at 58.7 Inches from the Nozzle and 375 KEAS Nozzle Airspeed

2. <u>475 KEAS and 58.7" from the Windblast Nozzle</u>: A mean velocity of 430 KEAS with a standard deviation of 21 KEAS was generated. The velocity decay from the nozzle to the test fixture was 45 KEAS. See Figure 3.

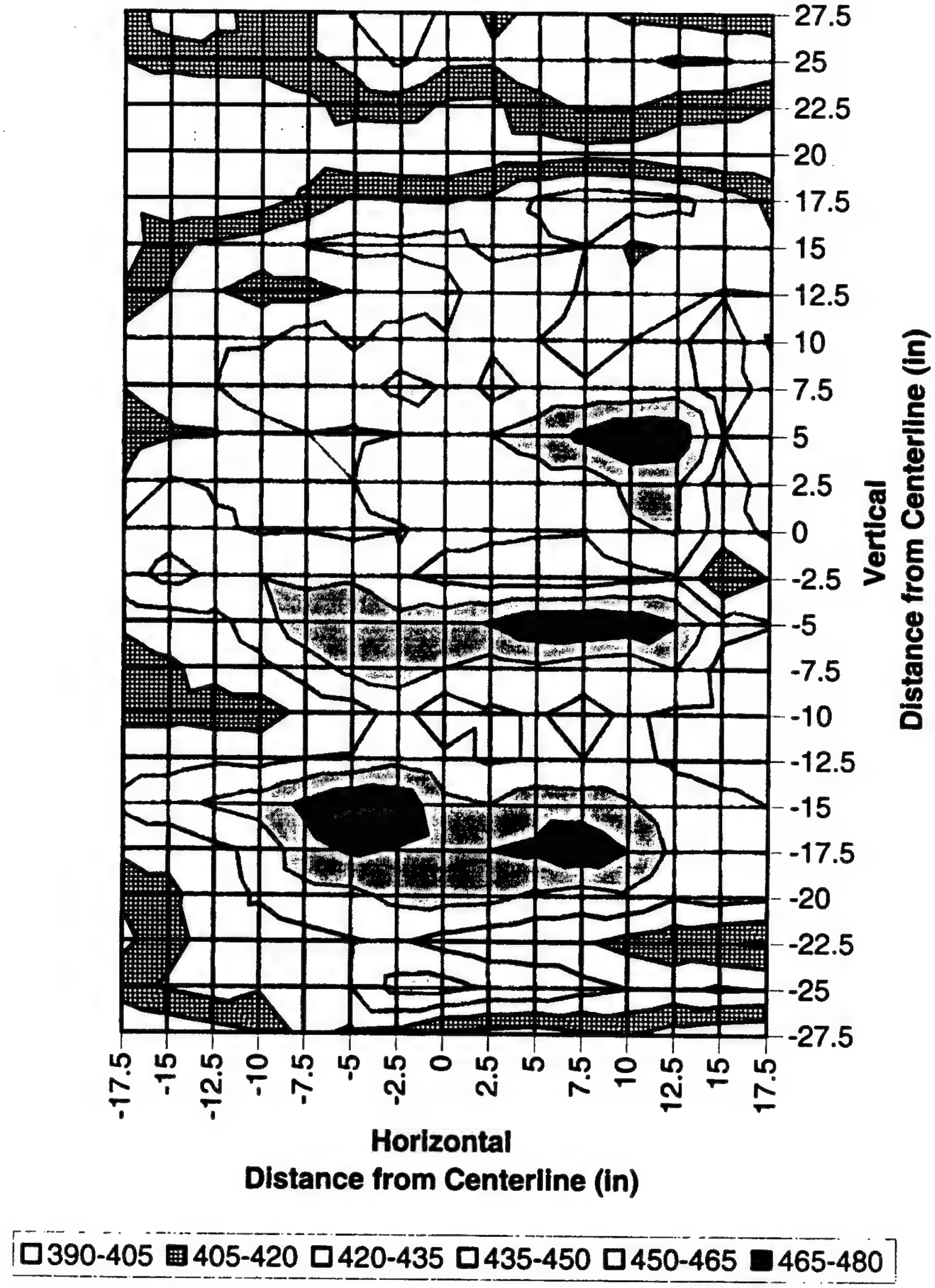

Figure 3. Velocity Profile (in KEAS) at 58.7 Inches from the Nozzle and 475 KEAS Nozzle Airspeed

3. 625 KEAS and 58.7" from the Windblast Nozzle: A mean velocity of 547 KEAS was obtained with standard deviation of 24 KEAS. The velocity decay from the nozzle to the test fixture was 78 KEAS. See Figure 4.

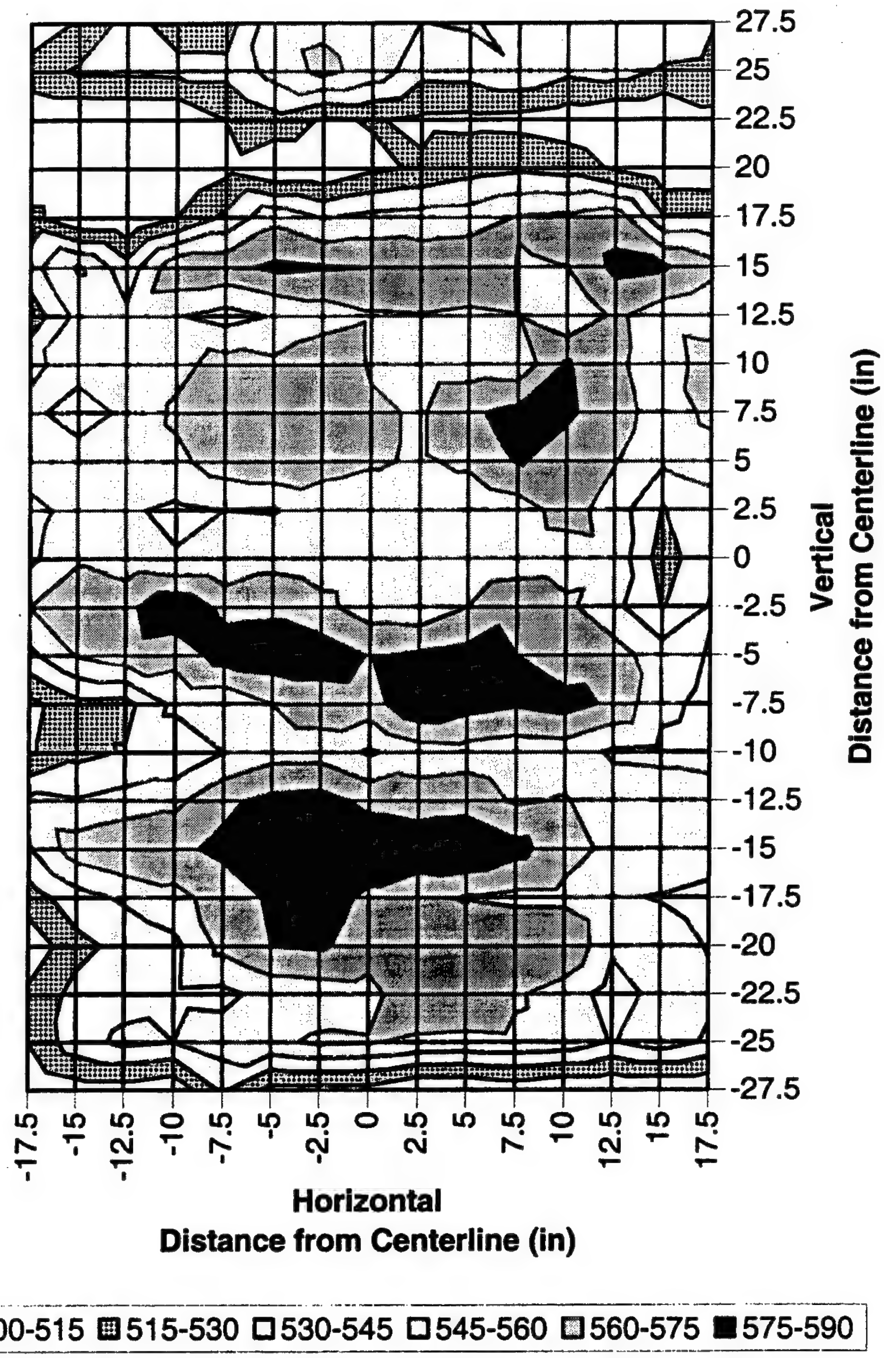

Figure 4. Velocity Profile (in KEAS) at 58.7 Inches from the Nozzle and 625 KEAS Nozzle Airspeed

4. <u>725 KEAS and 58.7" from the Windblast Nozzle</u>: The nozzle produced a mean velocity of 643 KEAS and a standard deviation of 26 KEAS. The velocity decay was 82 KEAS. See Figure 5.

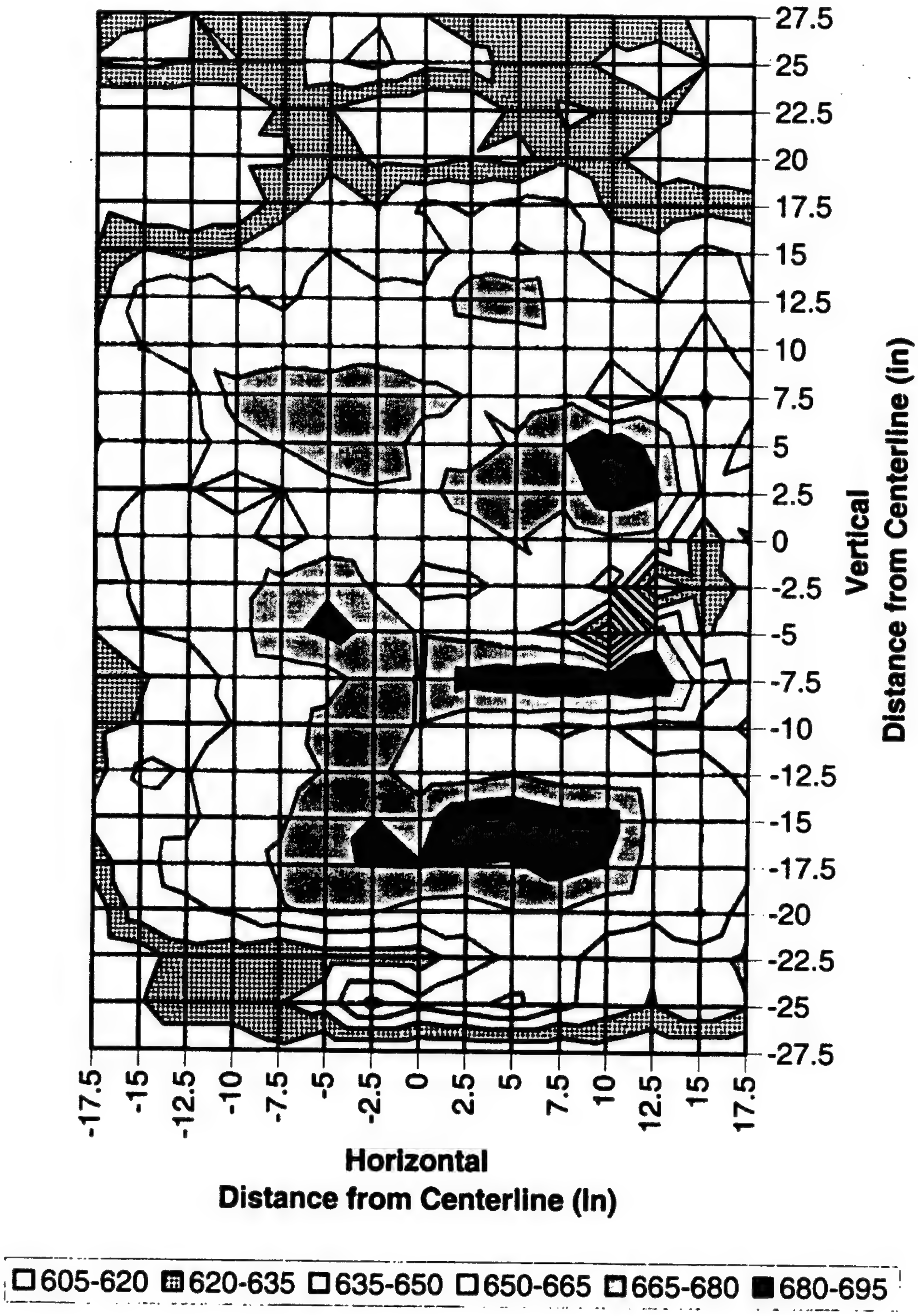

Figure 5. Velocity Profile (in KEAS) at 58.7 Inches from the Nozzle and 725 KEAS Nozzle Airspeed

Attempts were made at the end of the first test series to measure the airspeeds at distances of 24 and 72 inches from the windblast nozzle. This effort would allow a more complete understanding of the new facility in terms of airflow expansion and turbulence. However, some of the transducers located on the top row of the pressure rake produced erratic outputs. This problem was compounded with the compressor leakage, which was caused by a large number of tests being conducted at high speeds. Supplemental tests were conducted one year later to replace the erroneous sensor data at a pressure rake distance of 58.7 inches from the nozzle. However, no additional tests were performed at the other distances due to funding constraints. The following are summaries for the tests with the pressure rake placed at various distances from the nozzle.

5. <u>375 KEAS data at 24, 58.7, and 72 inches from the Windblast Nozzle</u>: The average velocities at 24, 58.7, and 72 inches from the nozzle are 425, 352, and 345 KEAS, showing velocity decays of 72 and 7 KEAS respectively (Figure 6). It was during these tests that a leak in the windblast compressor was discovered.

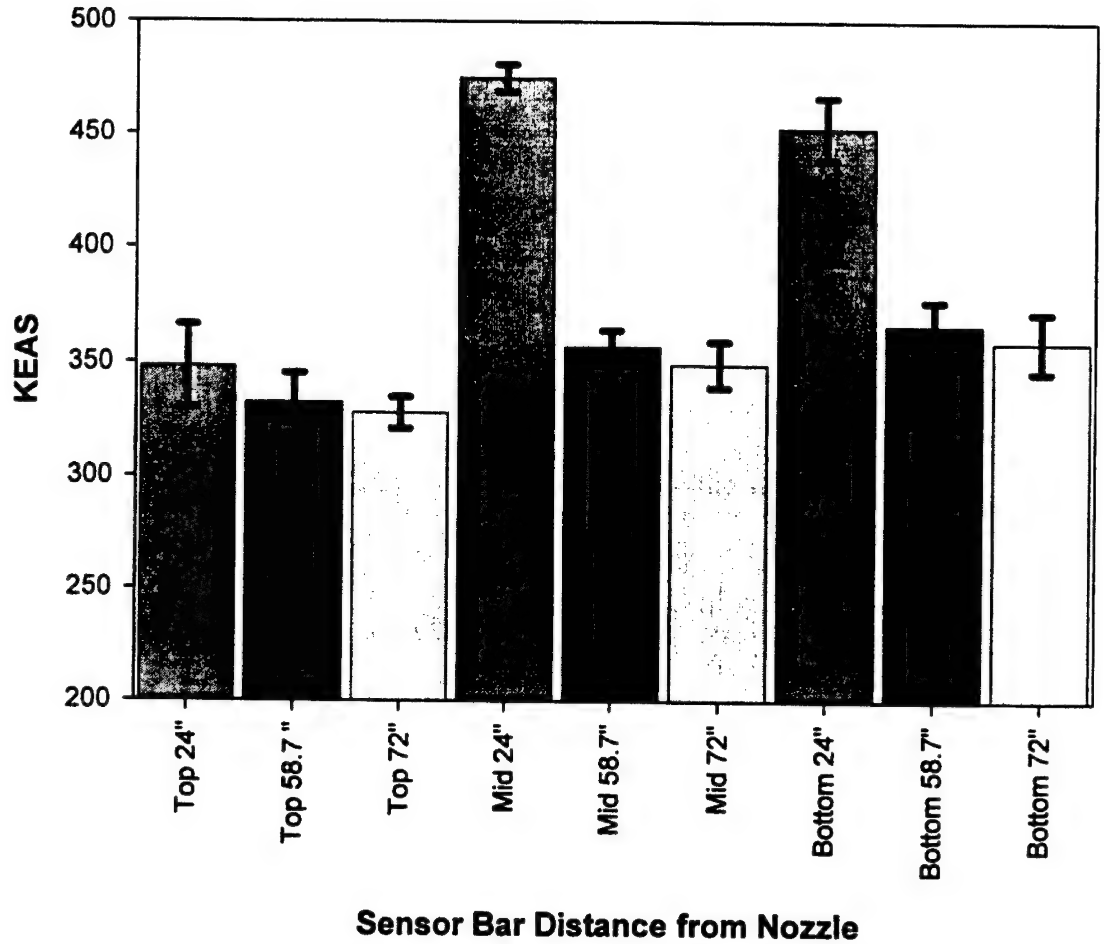

Figure 6. Average Velocity at 24, 58.7, and 72 Inches from the Nozzle for 375 KEAS Nozzle Airspeed. Note: The data at 24 inches from the nozzle for the mid and bottom row of sensors does not appear reliable. The velocities calculated at these locations are 475 and 452 KEAS which is not reasonable for a 375 KEAS nozzle airspeed.

6. <u>475 KEAS data at 24, 58.7, and 72 inches from the Windblast Nozzle</u>: The data collected at this test speed are much more reasonable than the data at 375 KEAS (Figure 7). The average velocities at 24, 58.7, and 72 inches from the nozzle are 435, 431, and 431 KEAS, showing velocity decays of 4 and 0 KEAS, respectively.

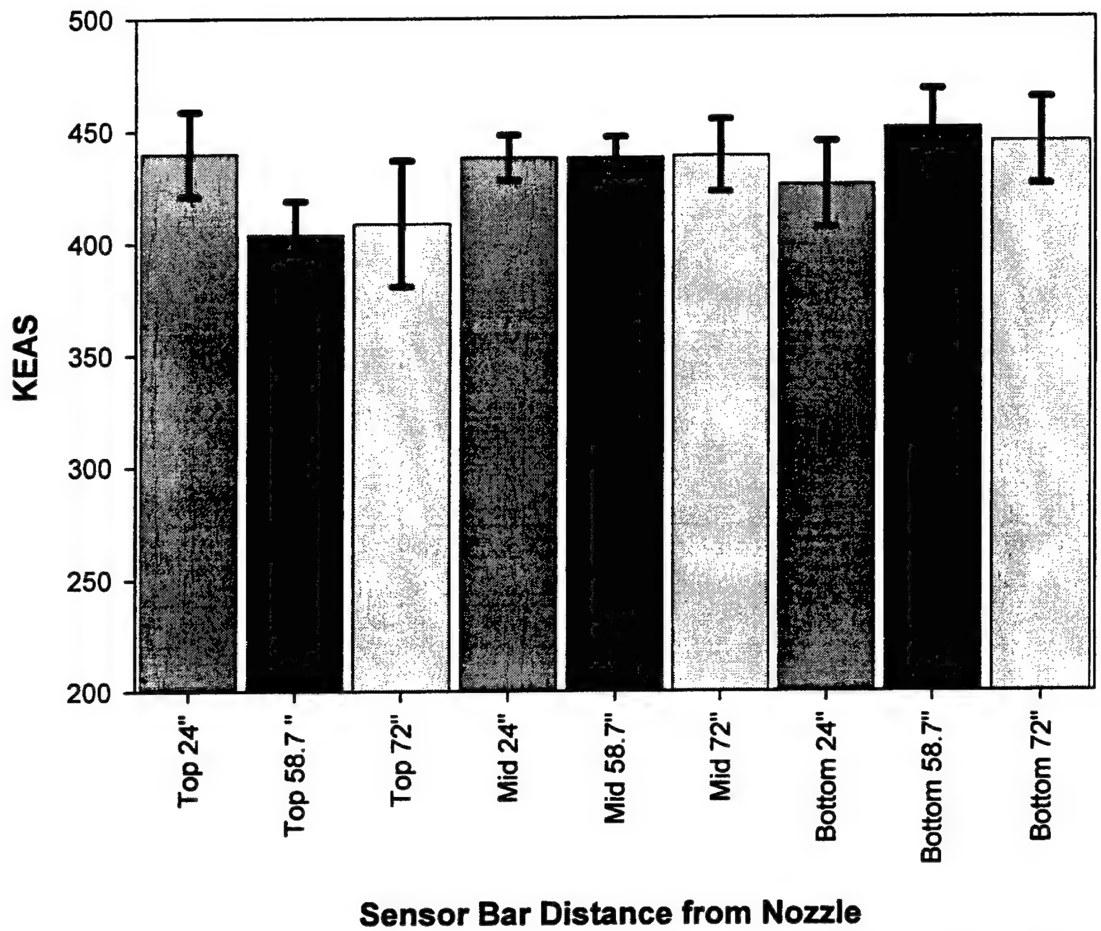

Figure 7. Average Velocity at 24, 58.7, and 72 Inches from the Nozzle for 475 KEAS Nozzle Airspeed. Note: There was no velocity decay calculated from 58.7 to 72 inches from the nozzle, which does not appear reasonable.

7. <u>625 KEAS data at 24, 58.7, and 72 inches from the Windblast Nozzle</u>: Similar to tests at 475 KEAS, data collected at this test speed are within expectation. Figure 8 shows that the airflow nearby (24 inches) and far away (72 inches) from the nozzle exhibits increased turbulence, resulting in higher standard deviations than the flow at mid-distance (58.7 inches). The average velocities for all sensors at 24, 58.7, and 72 inches from the nozzle are 565, 536, and 547 KEAS, showing velocity decays of 29 and -11 KEAS, respectively.

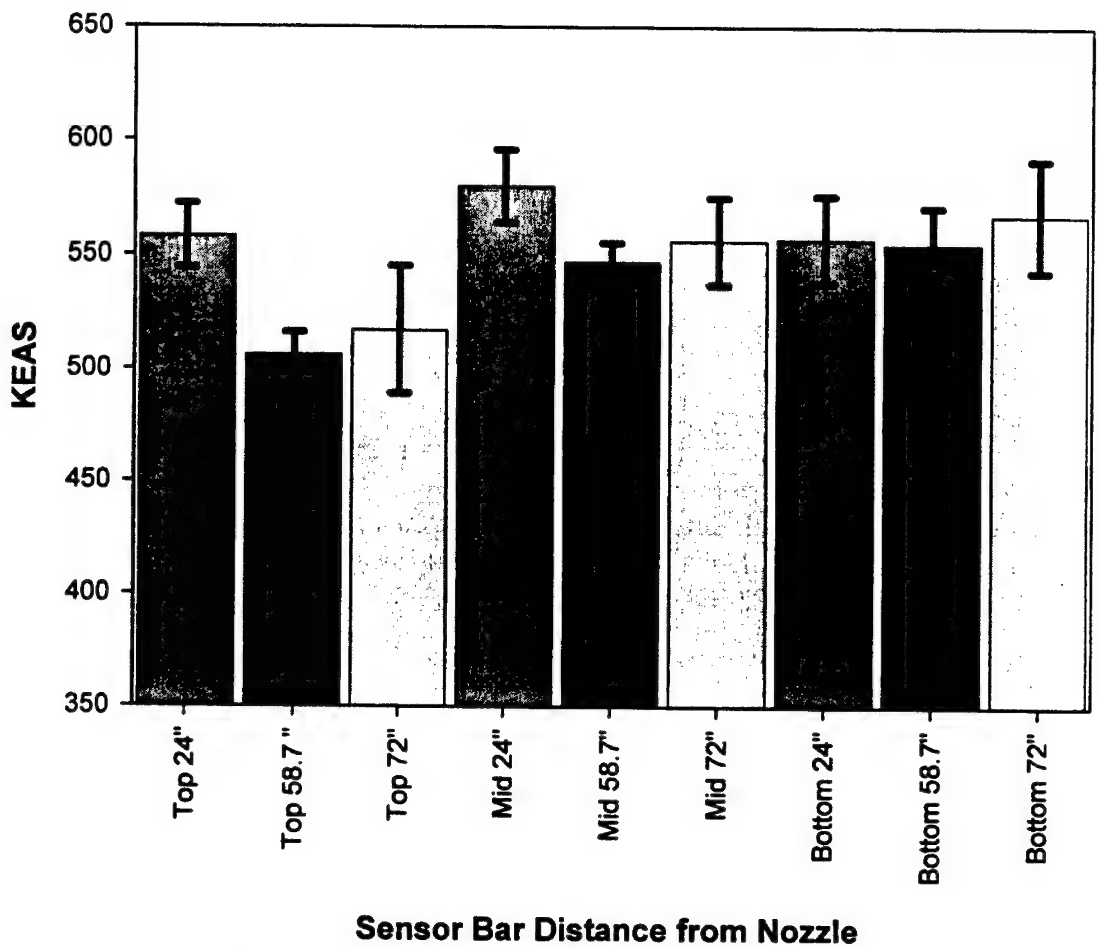

Figure 8. Average Velocity at 24, 58.7, and 72 Inches from the Nozzle for 625 KEAS Nozzle Airspeed. Note: A negative decay was calculated from 58.7 to 72 inches from the windblast nozzle. This is not possible and the data should be used with caution.

8. <u>725 KEAS data at 24 and 58.7 from the Windblast Nozzle</u>: The mean velocity of the bottom sensor bar was uncharacteristically lower at 24 inches from the nozzle than at 58.7 inches (Figure 9). This was the last test conducted in June 2000, at which point the compressor leakage had become excessive. As a result the test at 72 inches from the nozzle was not conducted. The average velocities for all sensors at 24 and 58.7 inches are 651 and 644 KEAS, showing a velocity decay of 7 KEAS.

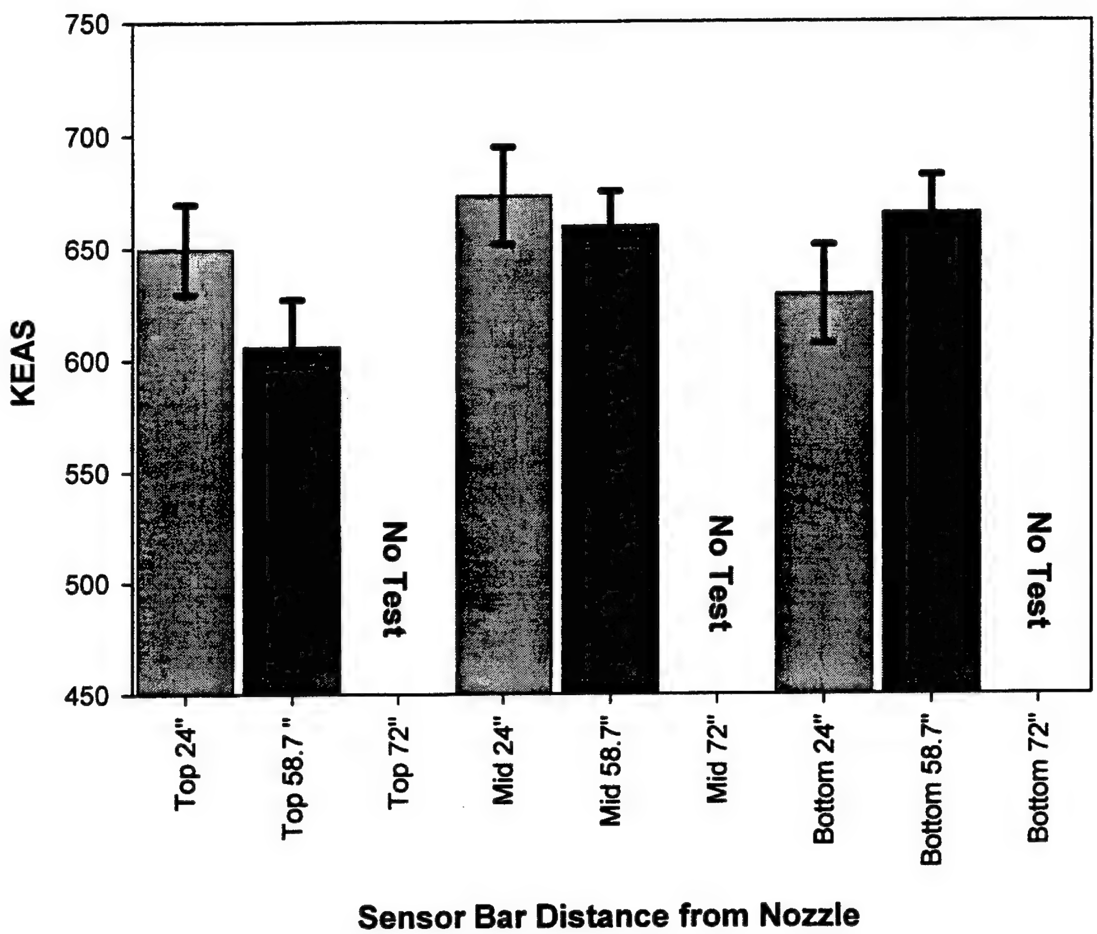

Figure 9. Average Velocity at 24 and 58.7 Inches from the Nozzle for 725 KEAS Nozzle Airspeed. Note: The calculated velocity at the bottom of the bar was lower at 24" away than at 58.7" away. This is again an unreasonable result.

CONCLUSION

Test data showed that with the new symmetrical airflow delivery system, the windblast facility has generated uniform airflow over the entire cross section of the nozzle at all measured test speeds (Figure 10). With a 50% wider nozzle, the airflow can fully cover the typical test article, including an ejection seat and seat subsystems, permitting the pitot interference potential to be accurately determined. This windblast facility can also produce 700 KEAS airflow, allowing it to accommodate more demanding future testing requirements.

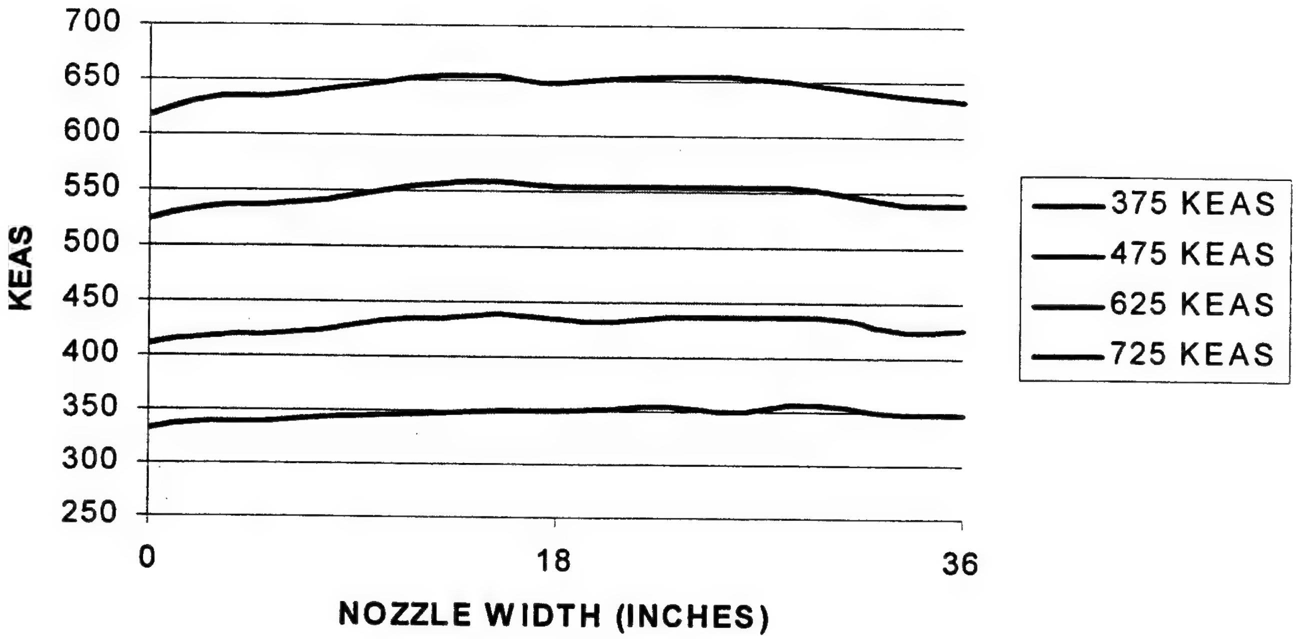

Figure 10. Mean velocity at 58.7 Inches downstream. Note the mean is the average velocity measured by all sensors at that horizontal position from the Windblast Nozzle

APPENDIX A

TEST CONDITION SUMMARY

Test Designation	CALA1	CALA2	CALA3	CALA4	CALA5	CALA6	CALA7	CALA8
Date	20 June 00	21 June 00	21 June 00	22 June 00	22 June 00	23 June 00	25 June 00	26 June 00
Distance from Nozzle (inches)	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	375	375	375	375	375	375	375	375
Main Rake Airspeed (KEAS)	368	364	368	363	372	362	372	367
Dynamic Correction Factor	1.0431	1.0679	1.0444	1.0748	1.0197	1.0793	1.0157	1.0466

Test Designation	CALB1	CALB2	CALB3	CALB4	CALB5	CALB6	CALB7	CALB8
Date	20 June 00	21 June 00	21 June 00	22 June 00	22 June 00	23 June 00	25 June 00	26 June 00
Distance from Nozzle (inches)	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	475	475	475	475	475	475	475	475
Main Rake Airspeed (KEAS)	480	475	468	472	471	478	466	476
Dynamic Correction Factor	0.9775	1.0000	1.0357	1.0140	1.0211	0.9875	1.0444	0.9966

Test Designation	CALC1	CALC2	CALC3	CALC4	CALC5	CALC6	CALC7	CALC8
Date	20 June 00	21 June 00	21 June 00	22 June 00	22 June 00	23 June 00	25 June 00	26 June 00
Distance from Nozzle (inches)	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	625	625	625	625	625	625	625	625
Main Rake Airspeed (KEAS)	638	626	623	638	622	633	612	628
Dynamic Correction Factor	0.9510	0.9946	1.0079	0.9499	1.0110	0.9683	1.0530	0.9904

Test Designation	CALD1	CALD2	CALD3	CALD4	CALD5	CALD6	CALD7	CALD8
Date	21 June 00	21 June 00	21 June 00	22 June 00	22 June 00	23 June 00	25 June 00	26 June 00
Distance from Nozzle (inches)	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	725	725	725	725	725	725	725	725
Main Rake Airspeed (KEAS)	706	716	715	715	716	724	719	719
Dynamic Correction Factor	1.0704	1.0315	1.0383	1.0365	1.0324	1.0051	1.0201	1.0218

Test Designation	CALE1	CALE2	CALF1	CALF2	CALG1	CALG2	CALH1	CALI1
Date	27 June 00	26 June 00	27 June 00	26 June 00	27 June 00	26 June 00	27 June 00	09 May 01
Distance from Nozzle (inches)	24	72	24	72	24	72	24	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	475	475	375	375	625	625	725	375
Main Rake Airspeed (KEAS)	470	478	288	360	616	623	723	384
Dynamic Correction Factor	1.0223	0.9886	1.7525	1.0953	1.0365	1.0073	1.0076	0.9486

Test Designation	CALI2	CALI3	CALJ1	CALJ2	CALJ3	CALK1	CALK2	CALK3
Date	09 May 01	10 May 01	09 May 01	09 May 01	10 May 01	09 May 01	09 May 01	10 May 01
Distance from Nozzle (inches)	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	375	375	475	475	475	625	625	625
Main Rake Airspeed (KEAS)	368	374	497	467	479	618	629	637
Dynamic Correction Factor	1.0423	1.0058	0.9034	1.0382	0.9831	1.0274	0.9862	0.9548

Test Designation	CALL1	CALL2	CALL3
Date	11 May 01	10 May 01	10 May 01
Distance from Nozzle (inches)	58.7	58.7	58.7
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level
Target Airspeed at Main Rake (KEAS)	725	725	725
Main Rake Airspeed (KEAS)	719	713	708
Dynamic Correction Factor	1.0201	1.0442	1.0637

APPENDIX B

COMPUTATIONAL FLUID DYNAMICS (CFD) ANALYSIS OF THE PRESSURE RAKE ASSEMBLY

CFD Analysis of Wind Tunnel Pressure Rake

Conducted by the AFRL/VAAC Computational Sciences Center of Excellence for AFRL/HEPA
Lt Ernest L. Foster II, Dr. Don W. Kinsey

Computational Fluid Dynamics (CFD) simulations were performed on a pressure rake designed by AFRL/HEPA using the ASC MSRC IBM SP2 high performance computer located at Wright-Patterson AFB. These tests were conducted in order to determine if the spacing between each sensor on the three bars attached to the pressure rake had a major influence on the neighboring sensors. Such an influence could result in a deviation of the readings obtained. Another objective was to determine if the distance between each pressure bar needed to be changed in order to prevent the same type of distortion during an actual wind tunnel test. Using the Cobalt60 CFD program with an Euler analysis it was found that the current geometry and spacing of the sensors do not provide any negative reactions at a maximum Mach of 1.06 with $\alpha = 0$.

A preliminary simulation on a single pressure bar was conducted using the ASC MSRC IBM SP3 also located at Wright-Patterson AFB. This test used the Turbulent Navier-Stokes equation set along with the Spalart-Allmaras turbulence model. This set of equations accounts for the viscous effects, where as the Euler equations do not. For simplicity the Euler equations were used for the final analysis since one of the major concerns was the pressure in front of each sensor. In this region it was assumed that there would not be much of a viscous effect. This was confirmed after comparing the two results. All other conditions remained the same for both simulations. Although the Navier-Stokes equation set provides a more accurate solution; both simulations displayed similar values, which verifies that there is no negative interaction among the sensors or bars.

Based on the simulations run, it was determined that this structure will also survive windblast testing. The only problem that was encountered with this rake was its bluntness especially at the leading edge. To minimize this problem for tests at higher Mach numbers, the structure will be made as flush and streamlined as possible. This will allow the flow over the sensors to be closer to that of the free stream conditions.

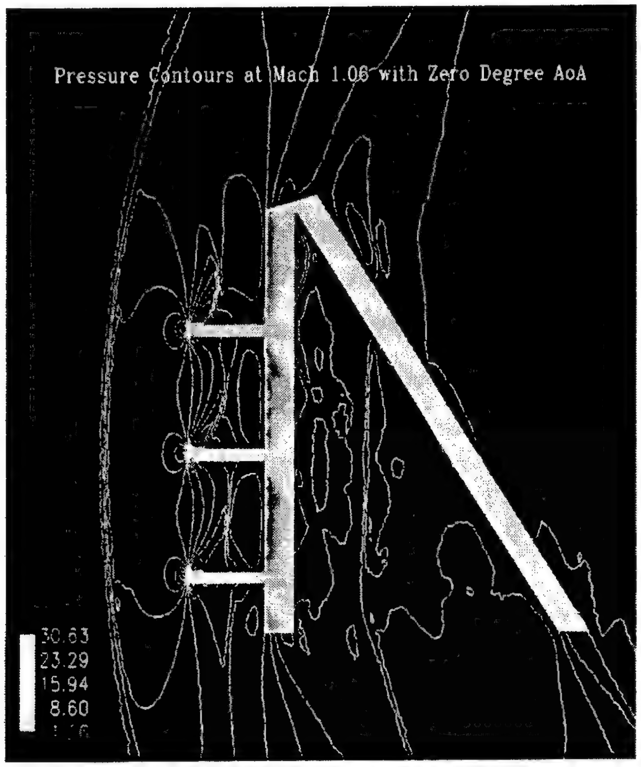

Figure B-1. The contour plane shown is slightly off center to reveal the most active area of the pressure rake. The values are in psi.

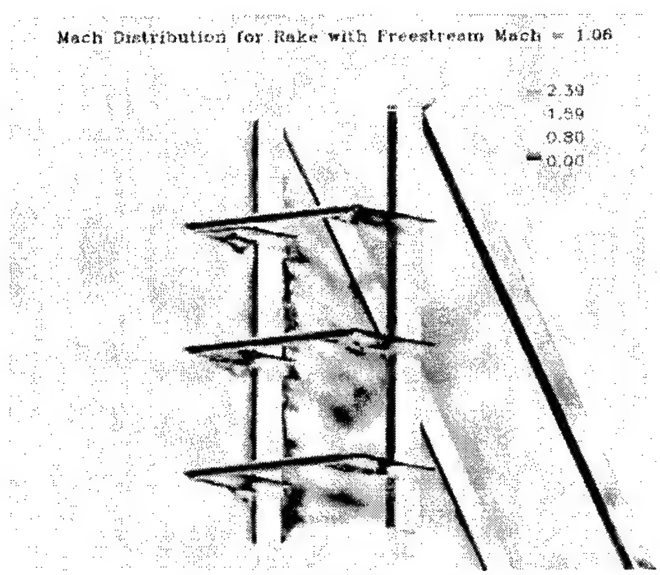

Figure B-2. Above is a picture showing the actual Mach number on and in the surrounding area of the rake.

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APPENDIX C

PEAK PRESSURE SUMMARY

VELOCITIES NORMALIZED TO 375 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
1	X	216	257	270	283	290	284	287	303	318	308	291	284	291	308	306	288	274	274	246	218			
2	X	263	290	326	336	338	332	327	345	357	349	340	334	342	343	344	344	334	337	301	261	1	339	8
3	X	282	315	334	338	341	336	335	342	354	349	338	338	341	339	342	349	351	354	311	X	2	342	6
4	228	271	312	337	323	308	322	333	344	350	352	348	341	329	328	328	325	323	320	303	264	3	333	13
5	202	255	295	323	300	301	302	316	329	325	327	331	342	342	348	337	330	324	318	294	268	4	325	15
6	208	256	295	324	309	314	318	329	341	338	343	339	350	355	355	351	341	344	333	302	270	5	337	15
7	205	251	294	327	336	335	333	340	343	340	343	348	354	312	349	341	354	344	322	286	X	6	340	11
8	227	265	312	339	350	341	342	341	345	344	349	354	356	320	346	349	345	343	331	301	X	7	344	8
9	232	286	320	334	342	339	343	347	347	346	354	359	358	355	361	364	347	364	341	295	263	8	351	9
10	238	268	304	335	342	346	352	353	356	359	356	353	355	361	377	375	356	369	338	311	276	9	356	11
11	222	260	303	336	344	339	349	352	345	348	344	344	342	344	356	362	346	352	324	301	271	10	347	7
12	217	273	336	356	360	357	361	357	356	356	357	353	347	351	371	371	345	358	335	298	264	11	357	7
13	221	279	322	350	351	344	341	342	339	344	347	345	348	344	358	361	334	352	324	293	258	12	347	7
14	224	279	320	357	361	360	360	360	363	365	366	368	365	362	379	384	352	373	332	305	279	13	365	8
15	214	256	299	329	346	349	357	365	363	368	364	356	363	366	357	363	339	339	324	296	260	14	355	12
16	223	266	308	338	356	348	355	363	361	359	355	358	368	364	368	382	354	355	344	307	273	15	359	10
17	209	265	315	333	336	342	346	348	354	352	349	349	351	346	349	351	350	337	325	286	244	16	346	6
18	201	258	314	347	347	346	344	353	357	356	354	373	374	369	368	361	361	361	327	297	263	17	358	10
19	218	261	304	326	344	352	360	360	362	360	360	371	369	366	362	358	365	354	319	279	248	18	358	11
20	235	272	309	346	352	358	366	379	383	375	363	368	373	372	376	361	355	367	347	289	250	19	366	10
21	212	249	297	327	340	346	344	351	353	355	352	347	346	345	347	346	348	348	317	274	241	20	346	7
22	204	242	305	333	345	352	351	346	348	353	361	368	373	372	360	359	354	352	332	288	235	21	355	11
23	X	X	272	321	324	332	337	340	334	347	348	359	357	359	349	343	343	316	301	X	X	22	341	13
24	X	X	258	292	322	335	340	337	310	316	310	330	325	324	331	335	338	328	293	X	X	23	325	13
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						
BOTTOM																						RIGHT		
Mean				333	339	340	343	347	349	351	350	352	353	350	356	355	347	347						
Std Dev				14	15	15	15	14	14	13	12	12	13	17	14	15	10	15						
AVG VEL (KEAS)			347																					
STD DEV (KEAS)			15																					

Table C-1. Nozzle Velocity (in KEAS) of 375 KEAS at 58.7 Inches Downstream

VELOCITIES NORMALIZED TO 475 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
	1	X	285	298	325	348	361	343	348	368	389	379	380	376	373	372	371	358	351	344	315	273			
	2	X	326	376	410	430	424	414	417	437	446	431	416	424	423	416	414	410	411	412	388	334	1	422	11
	3	X	339	376	406	412	415	415	417	425	439	424	423	427	430	433	437	436	431	432	395	X	2	425	10
	4	237	311	372	392	379	375	385	401	412	413	402	401	417	422	421	412	411	404	393	372	320	3	403	15
	5	244	300	346	369	359	350	363	395	388	388	385	396	396	400	399	392	383	372	359	337	309	4	382	16
	6	237	302	364	398	384	377	396	408	422	419	418	423	437	445	442	439	428	417	406	371	327	5	417	21
	7	247	310	362	396	417	423	428	436	439	438	441	429	432	435	417	422	426	422	401	360	X	6	427	12
	8	274	313	371	407	421	421	414	414	422	423	429	447	447	431	424	432	436	435	409	363	X	7	427	11
	9	297	349	389	426	429	431	432	442	432	442	436	438	435	424	435	439	422	452	408	376	336	8	434	8
	10	271	333	384	421	427	435	447	450	444	454	449	429	439	438	438	443	424	443	408	366	326	9	439	10
	11	257	324	377	412	418	419	427	435	433	435	444	450	457	469	488	478	435	438	410	372	325	10	443	22
	12	274	337	377	421	436	433	432	435	435	442	444	439	442	440	454	452	423	444	411	354	307	11	438	9
	13	268	334	398	437	444	437	433	434	431	434	439	439	437	436	448	451	427	438	396	371	325	12	438	6
	14	251	333	398	444	455	447	449	445	448	437	430	425	424	424	430	434	406	421	379	357	322	13	435	13
	15	274	335	394	426	428	431	443	461	459	454	459	466	478	480	476	466	440	436	423	378	320	14	454	18
	16	259	303	358	407	418	425	431	442	455	457	450	443	446	440	437	450	429	420	403	363	312	15	437	15
	17	265	296	370	416	416	413	413	424	427	441	422	433	436	431	437	432	431	427	400	350	302	16	427	9
	18	238	322	390	428	428	432	429	435	436	445	439	433	436	435	438	433	429	428	399	341	304	17	434	5
	19	275	333	401	438	445	452	457	468	480	477	454	450	460	459	452	441	439	435	396	352	310	18	454	14
	20	249	322	379	424	424	432	438	460	467	464	459	465	467	475	465	446	443	442	416	375	312	19	451	17
	21	258	308	372	407	417	427	437	445	446	454	456	455	447	443	447	436	440	437	414	341	284	20	440	14
	22	226	288	364	401	413	428	426	430	434	437	430	425	422	422	415	410	406	403	375	313	286	21	420	11
	23	X	X	365	413	422	428	422	423	435	455	456	448	448	440	435	431	437	434	401	X	X	22	435	13
	24	X	X	331	364	394	399	404	426	417	415	401	399	396	401	406	397	392	389	341	X	X	23	400	14
	25				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						
BOTTOM																							RIGHT		
Mean					411	418	420	423	432	436	440	435	434	437	437	437	434	424	425						
Std Dev					20	22	24	21	19	19	19	20	19	20	20	21	20	16	19						
AVG VEL (KEAS)				430																					
STD DEV (KEAS)				21																					

Table C-2. Nozzle Velocity (in KEAS) of 475 KEAS at 58.7 Inches Downstream

VELOCITIES NORMALIZED TO 625 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
1	X	364	382	422	446	458	458	470	483	481	463	458	453	464	464	436	434	434	440	400	367			
2	X	380	456	498	518	535	524	523	555	557	551	545	547	537	531	545	543	531	521	473	426	1	536	16
3	X	449	487	525	532	533	534	534	551	564	554	535	536	544	534	538	528	526	521	484	X	2	538	11
4	300	378	468	499	490	492	497	515	525	513	516	512	511	510	506	499	500	511	499	467	391	3	506	10
5	284	358	437	464	459	469	472	511	494	501	512	517	524	527	524	512	501	490	466	442	396	4	498	24
6	297	397	480	520	501	496	515	534	556	544	549	551	552	561	563	568	531	532	523	497	413	5	538	22
7	298	399	493	540	562	536	572	571	578	576	575	570	573	559	560	579	577	565	520	465	X	6	566	13
8	296	407	487	521	550	548	546	539	548	552	558	559	557	559	547	563	552	547	515	459	X	7	550	10
9	323	412	498	543	549	547	555	567	563	573	558	552	552	550	576	564	548	571	518	485	411	8	558	10
10	328	400	484	547	540	547	563	567	565	568	563	558	573	579	577	568	551	564	528	489	413	9	562	11
11	289	394	503	555	550	550	556	568	572	566	562	558	563	576	570	561	548	553	515	477	408	10	561	9
12	305	408	492	539	552	547	542	545	544	551	549	550	548	553	566	553	529	538	514	457	384	11	547	8
13	321	416	504	542	558	551	546	546	555	552	551	550	549	551	552	555	523	541	508	461	386	12	548	8
14	306	418	495	560	571	571	587	571	572	584	552	549	560	572	583	549	529	546	504	448	378	13	561	14
15	309	403	488	541	561	568	564	582	584	584	574	577	580	575	564	566	552	544	517	466	382	14	568	14
16	277	362	451	510	526	525	549	547	560	566	568	589	581	577	581	572	548	542	518	460	395	15	556	23
17	299	382	471	513	526	531	531	545	554	554	543	552	554	551	552	543	542	540	507	436	X	16	542	12
18	330	404	499	549	546	551	556	572	579	581	571	567	568	558	561	551	551	551	524	458	399	17	561	11
19	295	395	496	544	568	575	572	578	583	594	585	586	594	580	586	556	558	558	530	452	382	18	573	15
20	298	376	473	522	539	547	555	567	577	582	572	563	559	556	556	547	544	538	494	411	342	19	555	16
21	295	356	447	504	525	535	541	564	575	577	568	565	566	575	574	547	553	544	513	431	350	20	554	21
22	259	351	463	518	535	540	542	541	550	552	554	573	573	582	553	539	549	548	507	446	362	21	549	14
23	X	358	466	515	539	548	545	552	557	562	561	557	556	557	555	544	553	543	496	X	X	22	550	12
24	X	X	429	478	507	508	502	533	510	510	510	491	487	505	498	487	495	488	454	X	X	23	501	14
25				1	2	3	4	5	6	7	8	9	10	11	12	.13	14	15						
BOTTOM																						RIGHT		
Mean				524	535	537	542	551	557	568	555	553	555	555	553	548	539	540						
Std Dev				24	27	27	26	20	23	24	19	23	24	20	22	22	20	21						
AVG VEL (KEAS)			547																					
STD DEV (KEAS)			24																					

Table C-3. Nozzle Velocity (in KEAS) of 625 KEAS at 58.7 Inches Downstream

VELOCITIES NORMALIZED TO 725 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
1	X	405	454	515	534	536	530	527	150	567	536	531	544	550	575	589	549		527	471	404			
2	X	498	581	616	632	635	627	626	642	648	635	624	622	629	627	632	610	597	623	596	X	1	627	13
3	X	527	590	639	641	635	635	626	648	655	640	641	627	626	615	607	620	620	624	584.2	X	2	632	13
4	345	441	521	586	573	572	588	624	620	606	598	603	626	637	634	624	608	589	565	525	460	3	606	21
5	313	406	490	535	564	584	617	617	631	615	612	619	614	632	622	612	589	572	552	529.4	448	4	602	28
6	348	449	565	615	592	593	600	630	642	634	652	648	654	652	630	626	631	627	607	576	497	5	628	21
7	350	459	565	620	635	628	636	644	650	641	643	656	649	652	647	642	654	648	626	584	X	6	643	10
8	328	462	584	629	657	661	652	647	656	655	653	672	676	656	653	650	651	650	632	585.5	X	7	655	11
9	358	493	583	638	651	657	650	657	655	660	650	652	653	657	654	655	645	655	605	524.1	449	8	653	5
10	349	484	571	640	639	645	672	675	674	672	670	664	658	661	637	650	633	647	590	518.9	430	9	656	15
11	347	461	578	634	641	642	660	667	675	674	659	658	667	679	689	676	642	654	607	556.6	454	10	661	16
12	362	479	587	639	650	651	644	650	660	663	662	670	675	670	690	682	647	644	589	525.3	455	11	660	15
13	359	492	588	642	661	658	655	642	655	653	656	660	666	656	662	660	623	651	584	504.9	420	12	653	11
14	356	472	568	636	656	656	659	669	678	662	645	647	655	662	667	595	626	639	586	517.4	456	13	650	20
15	335	450	570	637	650	653	659	677	683	678	663	660	652	646	604	672	634	640	607	551.5	456	14	654	20
16	331	445	537	619	634	640	655	657	659	672	664	686	690	694	690	695	658	645	848	539.9	464	15	664	24
17	348	460	579	630	636	643	651	659	669	675	663	654	652	648	651	643	645	632	589	505.8	401	16	650	13
18	346	465	573	628	652	649	660	660	666	670	656	658	664	657	657	655	656	647	615	496.8	388	17	656	10
19	350	462	579	640	646	646	660	663	673	680	674	692	700	688	687	659	661	654	600	506.7	426	18	668	18
20	353	459	580	627	647	655	657	667	680	680	681	679	678	686	679	657	652	656	616	512.5	413	19	665	17
21	437	437	563	608	645	648	652	663	668	666	659	658	664	664	655	653	666	641	588	478.9	396	20	654	15
22	325	434	533	592	611	630	626	620	629	629	627	643	653	654	644	637	642	632	595	487.9	383	21	631	16
23	305	419	545	602	618	633	633	634	642	669	654	661	669	654	643	634	648	636	598	510.4	387	22	642	18
24	X	X	508	564	598	574	583	617	593	585	576	600	583	600	612	590	587	596	559	X	X	23	590	14
25				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						
BOTTOM																						RIGHT		
Mean				618	632	634	640	647	654	654	647	652	654	655	650	644	636	634						
Std Dev				27	27	27	24	20	22	25	25	23	26	21	26	27	22	23						
AVG VEL (KEAS)			643																					
STD DEV (KEAS)			26																					

Table C-4. Nozzle Velocity (in KEAS) of 725 KEAS at 58.7 Inches Downstream

VELOCITIES NORMALIZED TO 375 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
TOP 24"	369	49	299	318	340	359	363	338	313	335	335	358	365	373	360	360	347	364	465	364	263		348	18
TOP 58.7"	228	271	312	337	323	306	322	333	344	350	352	348	341	329	328	328	325	323	320	303	264		333	13
TOP 72"	291	215	284	314	327	331	334	330	325	325	324	339	338	336	331	325	318	324	361	285	257		328	7
MID 24"	236	393	474	487	474	477	469	460	481	480	475	478	470	473	475	475	477	476	474	468	333		475	6
MID 58.7"	217	273	336	356	360	357	361	357	356	356	357	353	347	351	371	371	345	358	335	298	264		357	7
MID 72"	222	265	299	330	339	344	349	353	352	351	356	355	349	352	381	371	343	335	306	283	261		349	10
BOTTOM 24"	X	X	430	444	430	452	451	461	467	462	460	467	467	475	457	426	439	449	X	X	X		452	14
BOTTOM 58.7"	235	272	309	346	352	358	366	379	383	375	363	388	373	372	376	361	355	367	347	289	250		366	10
BOTTOM 72"	X	X	310	327	347	356	362	372	370	366	367	367	366	368	369	358	348	341	X	X	X		369	13
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						

BOTTOM RIGHT

AVG VEL (KEAS) at 24"	425
AVG VEL (KEAS) at 58.7"	352
AVG VEL (KEAS) at 72"	345

Table C-5. Nozzle Velocity (in KEAS) of 375 KEAS at 24, 58.7, and 72 Inches Downstream

VELOCITIES NORMALIZED TO 475 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
TOP 24"	423	29.1	397	412	410	461	436	430	423	436	436	449	469	446	471	447	423	450	488	433	285		440	19
TOP 58.7"	237	311	372	392	379	375	385	414	412	413	402	401	417	422	421	412	411	404	393	372	320		404	15
TOP 72"	279	247	342	367	403	418	419	455	394	439	383	407	431	414	404	455	370	377	406	327	263		409	28
MID 24"	196	369	426	443	427	437	429	420	437	454	439	453	443	434	453	442	428	435	434	431	297		438	10
MID 58.7"	274	337	377	421	436	433	432	435	435	442	444	439	442	440	454	452	423	444	411	354	307		438	9
MID 72"	249	315	369	400	423	430	437	443	443	443	447	449	451	454	456	459	432	417	388	349	305		439	16
BOTTOM 24"	423	449	471	447	423	450	442	433	415	415	397	412	410	461	436	430	423	398	372	469	446		426	19
BOTTOM 58.7"	249	322	379	424	424	432	438	460	467	464	459	465	467	475	465	446	443	442	416	375	312		451	17
BOTTOM 72"	X	X	367	410	436	448	458	468	472	470	462	451	443	444	440	434	428	413	370	X	X		445	19
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						
BOTTOM																						RIGHT		

AVG VEL (KEAS) at 24"	435
AVG VEL (KEAS) at 58.7"	431
AVG VEL (KEAS) at 72"	431

Table C-6. Nozzle Velocity (in KEAS) of 475 KEAS at 24, 58.7, and 72 Inches Downstream

VELOCITIES NORMALIZED TO 625 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
TOP 24"	X	X	X	558	558	558	569	557	545	548	550	554	571	548	597	570	542	550	555	560	395		558	14
TOP 58.7"	300	378	468	499	490	492	497	515	525	513	516	512	511	510	506	499	500	511	499	467	391		506	10
TOP 72"	346	354	433	515	542	523	531	544	500	523	465	469	549	524	520	562	486	509	532	436	368		517	28
MID 24"	222	487	533	578	570	586	578	569	589	609	581	607	603	562	563	584	567	576	566	557	X		580	16
MID 58.7"	305	408	492	539	552	547	542	545	544	551	549	550	548	553	566	553	529	538	514	457	384		547	8
MID 72"	333	411	474	524	551	560	563	566	584	575	573	583	562	562	556	581	529	516	498	453	X		556	19
BOTTOM 24"	X	X	546	545	522	560	561	551	579	589	557	574	534	572	592	537	544	581	X	X	X		557	19
BOTTOM 58.7"	298	376	473	522	539	547	555	567	577	582	572	563	559	566	558	547	544	538	494	411	342		555	16
BOTTOM 72"	X	X	484	519	543	559	567	574	581	587	575	583	593	601	586	568	552	524	480	X	X		567	24
BOTTOM				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				RIGHT		

AVG VEL (KEAS) at 24"	565
AVG VEL (KEAS) at 58.7"	536
AVG VEL (KEAS) at 72"	547

Table C-7. Nozzle Velocity (in KEAS) of 625 KEAS at 24, 58.7, and 72 Inches Downstream

VELOCITIES NORMALIZED TO 725 KEAS RAKE VELOCITY

30 INCHES CENTERED ABOUT C/L OF NOZZLE

LEFT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOP	Mean	Std Dev
TOP 24"	X	549	614	645	667	690	642	636	631	667	660	606	647	648	648	658	668	631	664	617	430		650	20
TOP 58.7"	345	441	521	586	573	572	588	624	620	606	598	603	626	637	634	624	608	589	565	525	460		606	21
TOP 72"																								
MID 24"	242	548	648	660	655	669	661	653	710	704	670	713	698	664	664	665	655	658	653	653	369		673	21
MID 58.7"	362	479	587	639	650	651	644	650	660	663	662	670	675	670	690	682	647	644	589	525	455		660	15
MID 72"																								
BOTTOM 24"	X	X	589	618	599	614	624	598	659	634	615	662	619	632	571	614	641	637	X	636	X		629	22
BOTTOM 58.7"	353	459	580	627	647	655	657	667	680	680	681	679	678	686	679	657	652	656	616	513	413		665	17
BOTTOM 72"																								
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						
BOTTOM																						RIGHT		

AVG VEL (KEAS) at 24" 651
AVG VEL (KEAS) at 58.7" 644

Table C-8. Nozzle Velocity (in KEAS) of 375 KEAS at 24 and 58.7 Inches Downstream

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APPENDIX D

CHANNEL DEFINITION/CALIBRATION

Test Program: Windblast Facility Evaluation
Test Designation:
Test Date: June 19-27, 2000;May 7-11, 2001
Test Velocity: 375 - 725 KEAS
Data/Filter Rate: 5,000 Hz/2,000 Hz
Trigger: Keyboard, T-10 seconds

Channel	Ch Sym	Channel Description	Sensor	S/N	Units	Excitation	Sensitivity	Resistance	Range
1	A1	Sensor A1 Pressure	Kulite XT-190-25SG	4073-4-123	PSI	10 V	0.4011	229	+/- 15
2	A2	Sensor A2 Pressure	Kulite XT-190-25SG	4073-4-128	PSI	10 V	0.3842	235	+/- 15
3	B1	Sensor B1 Pressure	Kulite XT-190-25SG	4073-4-131	PSI	10 V	0.3849	236	+/- 15
4	B2	Sensor B2 Pressure	Kulite XT-190-25SG	4073-4-135	PSI	10 V	0.3842	246	+/- 15
5	C1	Sensor C1 Pressure	Kulite XT-190-25SG	4073-4-137	PSI	10 V	0.4301	262	+/- 15
6	C2	Sensor C2 Pressure	Kulite XT-190-25SG	4073-4-139	PSI	10 V	0.4153	230	+/- 15
7	C3	Sensor C3 Pressure	Kulite XT-190-25SG	4073-4-144	PSI	10 V	0.3754	803	+/- 15
8	MRP	Main Rake Pressure	Kulite XT-190-25SG	4073-4-147	PSI	10 V	0.3838	238	+/- 15
9	A3	Sensor A3 Pressure	Kulite XT-190-25SG	4073-4-149	PSI	10 V	0.3793	238	+/- 15
10	A4	Sensor A4 Pressure	Kulite XT-190-25SG	4073-4-151	PSI	10 V	0.4939	248	+/- 15
11	A5	Sensor A5 Pressure	Kulite XT-190-25SG	4073-4-155	PSI	10 V	0.3611	240	+/- 15
12	A6	Sensor A6 Pressure	Kulite XT-190-25SG	4073-4-156	PSI	10 V	0.3391	241	+/- 15
13	A7	Sensor A7 Pressure	Kulite XT-190-25SG	4073-4-157	PSI	10 V	0.3817	433	+/- 15
14	A8	Sensor A8 Pressure	Kulite XT-190-25SG	4073-4-160	PSI	10 V	0.3716	235	+/- 15
15	A9	Sensor A9 Pressure	Kulite XT-190-25SG	4073-4-161	PSI	10 V	0.3871	242	+/- 15
16	A10	Sensor A10 Pressure	Kulite XT-190-25SG	4073-4-162	PSI	10 V	0.3968	241	+/- 15
17	A11	Sensor A11 Pressure	Kulite XT-190-25SG	5236-3A-102	PSI	10 V	0.3942	376	+/- 15
18	A12	Sensor A12 Pressure	Kulite XT-190-25SG	5236-3A-119	PSI	10 V	0.3693	235	+/- 15
19	A13	Sensor A13 Pressure	Kulite XT-190-25SG	5350-6-254	PSI	10 V	0.3779	542	+/- 15
20	A14	Sensor A14 Pressure	Kulite XT-190-25SG	5350-6-255	PSI	10 V	0.3788	466	+/- 15
21	A15	Sensor A15 Pressure	Kulite XT-190-25SG	5350-6-256	PSI	10 V	0.3792	585	+/- 15
22	A16	Sensor A16 Pressure	Kulite XT-190-25SG	5350-6-259	PSI	10 V	0.3769	642	+/- 15
23	A17	Sensor A17 Pressure	Kulite XT-190-25SG	5572-3-59	PSI	10 V	0.3553	407	+/- 15
24	A18	Sensor A18 Pressure	Kulite XT-190-25SG	5572-3-63	PSI	10 V	0.3549	368	+/- 15
25	B3	Sensor B3 Pressure	Kulite XT-190-25SG	5572-3-66	PSI	10 V	0.3704	400	+/- 15
26	B4	Sensor B4 Pressure	Kulite XT-190-25SG	5572-3-68	PSI	10 V	0.3568	402	+/- 15
27	B5	Sensor B5 Pressure	Kulite XT-190-25SG	5572-3-67	PSI	10 V	0.3618	335	+/- 15
28	B6	Sensor B6 Pressure	Kulite XT-190-25SG	5572-3-70	PSI	10 V	0.3574	676	+/- 15
29	B7	Sensor B7 Pressure	Kulite XT-190-25SG	5572-3-221	PSI	10 V	0.3979	530	+/- 15
30	B8	Sensor B8 Pressure	Kulite XT-190-25SG	5572-3-224	PSI	10 V	0.3587	421	+/- 15
31	B9	Sensor B9 Pressure	Kulite XT-190-25SG	5580-4C-95	PSI	10 V	0.3933	348	+/- 15
32	B10	Sensor B10 Pressure	Kulite XT-190-25SG	5580-4C-101	PSI	10 V	0.4124	381	+/- 15

Channel	Ch Syn	Channel Description	Sensor	S/N	Units	Excitation	Sensitivity	Resistance	Range
33	B11	Sensor B11 Pressure	Kulite XT-190-25SG	5941-1-114	PSI	10 V	0.3409	681	+/- 15
34	B12	Sensor B12 Pressure	Kulite XT-190-25SG	5941-1-115	PSI	10 V	0.3354	910	+/- 15
35	B13	Sensor B13 Pressure	Kulite XT-190-25SG	5941-1-116	PSI	10 V	0.3344	689	+/- 15
36	B14	Sensor B14 Pressure	Kulite XT-190-25SG	5941-1-118	PSI	10 V	0.3382	646	+/- 15
37	B15	Sensor B15 Pressure	Kulite XT-190-25SG	5941-1-119	PSI	10 V	0.3396	594	+/- 15
38	B16	Sensor B16 Pressure	Kulite XT-190-25SG	5941-1-121	PSI	10 V	0.3352	1008	+/- 15
39	B17	Sensor B17 Pressure	Kulite XT-190-25SG	5941-1-122	PSI	10 V	0.3388	480	+/- 15
40	B18	Sensor B18 Pressure	Kulite XT-190-25SG	5941-1-123	PSI	10 V	0.3378	765	+/- 15
41	C4	Sensor C4 Pressure	Kulite XT-190-25SG	5941-1-124	PSI	10 V	0.3358	611	+/- 15
42	C5	Sensor C5 Pressure	Kulite XT-190-25SG	5941-1-125	PSI	10 V	0.3396	804	+/- 15
43	C6	Sensor C6 Pressure	Kulite XT-190-25SG	5941-1-126	PSI	10 V	0.3365	776	+/- 15
44	C7	Sensor C7 Pressure	Kulite XT-190-25SG	5941-1-127	PSI	10 V	0.3307	838	+/- 15
45	C8	Sensor C8 Pressure	Kulite XT-190-25SG	5941-1-128	PSI	10 V	0.3367	678	+/- 15
46	C9	Sensor C9 Pressure	Kulite XT-190-25SG	5941-1-129	PSI	10 V	0.3411	617	+/- 15
47	C10	Sensor C10 Pressure	Kulite XT-190-25SG	5941-1-130	PSI	10 V	0.3386	711	+/- 15
48	C11	Sensor C11 Pressure	Kulite XT-190-25SG	5941-1-133	PSI	10 V	0.3395	694	+/- 15
49	C12	Sensor C12 Pressure	Kulite XT-190-25SG	5941-1-135	PSI	10 V	0.3370	579	+/- 15
50	C13	Sensor C13 Pressure	Kulite XT-190-25SG	5957-4-259	PSI	10 V	0.3372	689	+/- 15
51	C14	Sensor C14 Pressure	Kulite XT-190-25SG	5957-4-260	PSI	10 V	0.3357	603	+/- 15
52	C15	Sensor C15 Pressure	Kulite XT-190-25SG	5957-4-261	PSI	10 V	0.3376	729	+/- 15
53	C16	Sensor C16 Pressure	Kulite XT-190-25SG	5957-4-262	PSI	10 V	0.3391	696	+/- 15
54	C17	Sensor C17 Pressure	Kulite XT-190-25SG	6224-1-310	PSI	10 V	0.3415	664	+/- 15
55	C18	Sensor C18 Pressure	Kulite XT-190-25SG	6224-1-311	PSI	10 V	0.3407	606	+/- 15
56	C19	Sensor C19 Pressure	Kulite XT-190-25SG	6224-1-313	PSI	10 V	0.3392	723	+/- 15
57	A19	Sensor A19 Pressure	Kulite XT-190-25SG	6224-1-314	PSI	10 V	0.3386	751	+/- 15
58	A20	Sensor A20 Pressure	Kulite XT-190-25SG	6224-1-315	PSI	10 V	0.3387	655	+/- 15
59	A21	Sensor A21 Pressure	Kulite XT-190-25SG	6224-1-316	PSI	10 V	0.3419	740	+/- 15
60	B19	Sensor B19 Pressure	Kulite XT-190-25SG	6224-1-317	PSI	10 V	0.3410	752	+/- 15
61	B20	Sensor B20 Pressure	Kulite XT-190-25SG	6224-1-318	PSI	10 V	0.3406	735	+/- 15
62	B21	Sensor B21 Pressure	Kulite XT-190-25SG	6224-1-319	PSI	10 V	0.3701	737	+/- 15
63	C20	Sensor C20 Pressure	Kulite XT-190-25SG	6224-1-320	PSI	10 V	0.3405	713	+/- 15
64	C21	Sensor C21 Pressure	Kulite XT-190-25SG	6224-1-321	PSI	10 V	0.3387	605	+/- 15